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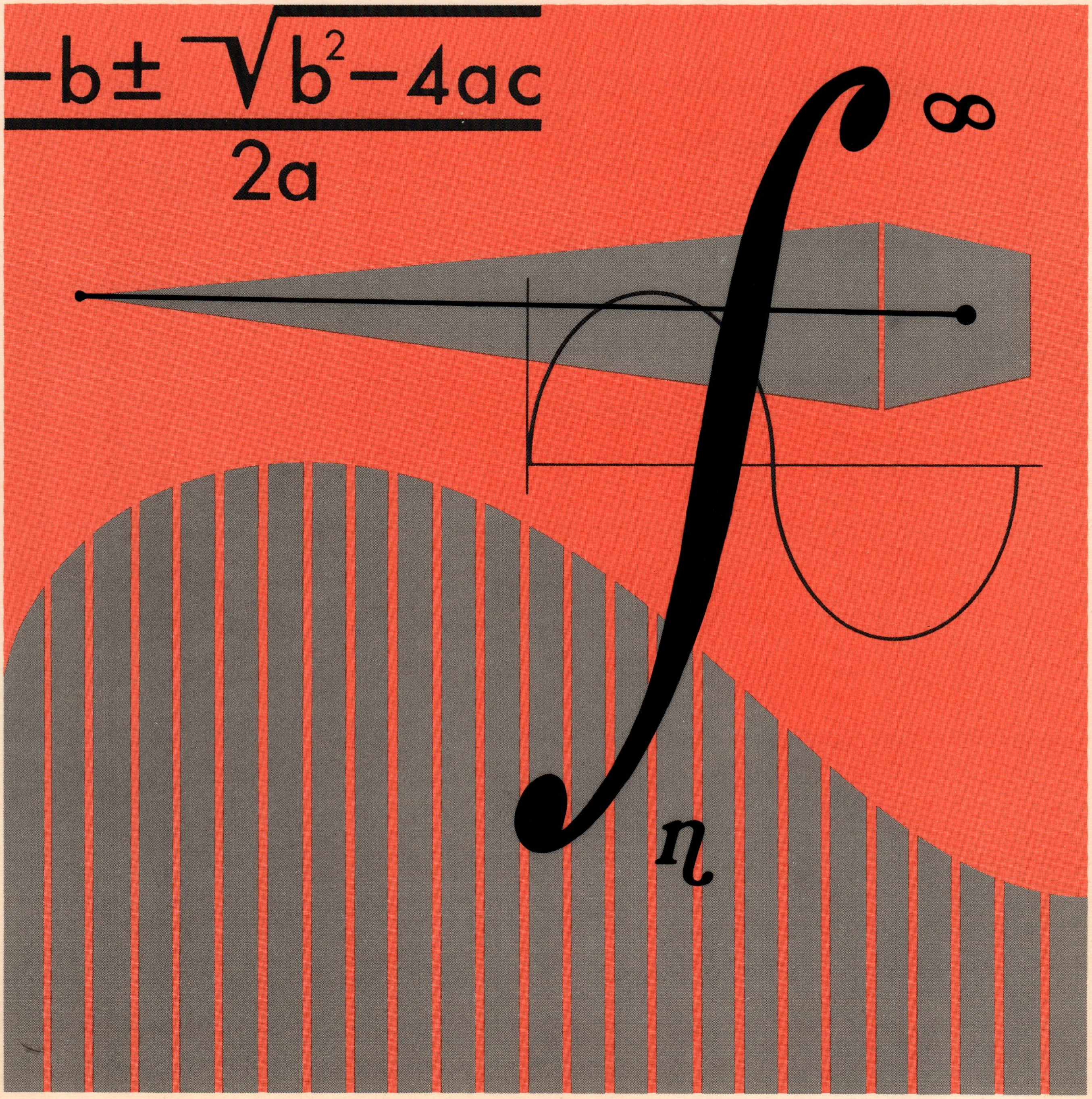
BASIC Application Programs—Mathematics II



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DEC EDUCATIONAL PUBLICATIONS

Other publications in the continuing series of curriculum material published by DEC for use with EduSystems 10 through 80 are listed below. Please inquire directly for prices on classroom quantities.

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BASIC APPLICATION PROGRAMS

The programs contained in this series are designed to demonstrate how the computer can be applied in a meaningful way to problems of many disciplines. The problems and the corresponding programs are, for the most part, quite simple and are designed to be "jumping off points" for students from the high school level on up.

All of the programs, with very few exceptions, may be run on EduSystems 10 through 80, PDP-8 Family and PDP-11 Family computers. Exceptions are noted in the program descriptions.

DEC welcomes contributions of programs and write-ups for use in this series. Contributors will be credited as program "Source". Please send programs and descriptions to Educational Marketing (5-2).

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MATHEMATICS II

Mathematics	BOOKS	Demonstrates method of improving upon brute force to solve simultaneous equations.
	DISTANCE	Calculates distance between points in three-dimensional space.
	EXPON	Solves for the exponent in general exponential equations.
	GOLDBACH	Tests Goldbach's conjecture up to 50.
	GROUP	Demonstrates brute force vs. substitutional solution of simple equations.
	PASCAL	Method of generating Pascal's triangle using random numbers.
	PROGRS	Solves a number progression problem.
	QUADRT	Solves for the roots of a quadratic equation.
	TUTOR-1	Drill and practice with time-speed-distance problems.
Geometry	CRSCNT	Solves for the area of a crescent (not generalized).
Statistics	FLIP-1	Flips a coin.
Graphing	SINEX	Plots a sine wave.
	3DPLOT	Plots any three-dimension functions.

AREA: Mathematics NUMBER: 8-3 NAME: BOOKS
SOURCE: Digital Equipment Corporation LANGUAGE: BASIC

DESCRIPTION: This program illustrates the solution to a fairly simple word problem involving two simultaneous equations. Then, by combining the equations and trying fewer combinations, the speed of obtaining the solution can be improved 100 fold. The problem is:

Brown has 48 books; some are worth $3 each, some $5 and others $8. The total value of the books is $175. How many of each kind are there if there are an even number of $5 books?

USAGE: The equations for solution are (letting T = number of three dollar books; F = five dollar books and E = eight dollar books):

$$T + F + E = 48$$

$$T * 3 + F * 5 + E * 8 = 175$$

If we then try all possible combinations of T, F, and E from 1 to 48 for each variable, our program would be as follows:

```
 5 PRINT "ALL POSSIBLE SOLUTIONS FOR BOOKS PROBLEM"
 6 PRINT
 7 PRINT "T","F","E"
8  PRINT
10 FOR T=1 TO 48
20 FOR F=1 TO 48
30 FOR E=1 TO 48
40 IF (T+F+E)<>48 THEN 70
50 IF (T*3+F*5+E*8)<>175 THEN 70
60 PRINT T,F,E
70 NEXT E
80 NEXT F
90 NEXT T
99 END
```

```
RUN

BOOKS           21:03           22-JAN-71


ALL POSSIBLE SOLUTIONS FOR BOOKS PROBLEM

T               F               E

 34              13              1
 37              8               3
 40              3               5

TIME:  7.31 SECS.

READY
```

However, 7.31 seconds is a long time for the computer to work. Let's solve for T in both equations by hand and solve the resulting equation by brute force on the computer:

$$F * 2 + E * 5 = 31$$

In this equation, we can also reduce our limits since we recognize that F cannot be greater than 31/2 = 15.5 and E cannot be greater than 31/5 = 6.2. Making the appropriate program modifications leads to:

```
10
20 FOR F=1 TO 15
30 FOR E=1 TO 6
40 IF (F*2+E*5)<>31 THEN 70
50
55 LET T=48-F-E
90

RUN

BOOKS           21:06           22-JAN-71


ALL POSSIBLE SOLUTIONS FOR BOOKS PROBLEM

T               F               E

 40              3               5
 37              8               3
 34              13              1

TIME:  0.16 SECS.

READY
```

Our final refinement is to step F in increments of 2 since we know it must be even.

```
5 PRINT "SOLUTIONS FOR BOOKS PROBLEM WITH F = EVEN NUMBER"
20 FOR F=2 TO 14 STEP 2

RUN

BOOKS           21:10           22-JAN-71



SOLUTIONS FOR BOOKS PROBLEM WITH F = EVEN NUMBER

T               F               E

 37              8               3

TIME:  0.06 SECS.

READY
```

3

EDUCATIONAL BENEFIT: Notice the enormous improvement in computing time required for a solution 7.31 seconds to .06 seconds. Brute force certainly is inefficient! Perhaps it's worthwhile to think through most problems, particularly big ones. The computer may be fast, but we just improved its performance by 100 times using a little common sense!

AREA: Mathematics
NUMBER:
NAME: DISTANCE
SOURCE: Digital Equipment Corp.
LANGUAGE: BASIC

DESCRIPTION: This program solves for the distance between two points in 3-dimensional space defined by their x, y, z coordinates.

APPROACH: The distance between two points in 3-dimensional space may be found by the formula:

$$d = (x_2-x_1)^2 + (y_2-y_1)^2 + (z_2-z_1)^2$$

Program distance solves the equation for three sets of points with the following coordinates:

P (0,0,0)	and Q (3, 4, 5)
A (3.5, -4.7, 6.2)	and B (0.9, 3.0, 4.4)
X (67, 36, 82	and Y (54, 25, 90)

Notice how we have used a DATA statement to define the points. Is this a good "general" approach? Modify the program to accept any two sets of x, y, z coordinates at the time the program is run and output the distance.

This calculation is used extensively in aerospace navigation. A good exercise for advanced students is determining the angle or "compass heading" of the resulting path. Better start first with just two dimensions!

```
10 FOR N=1 TO 3
15 PRINT
20 READ A,B,C,D,E,F
30 LET D1=SQR((A-D)↑2+(B-E)↑2+(C-F)↑2)
40 PRINT "THE DISTANCE BETWEEN ("A","B","C") AND ("D","E","F")"
45 PRINT "IS"D1
50 NEXT N
60 DATA 0,0,0,3,4,5,3.5,-4.7,6.2,-.9,3,4.4,67,36,82,54,25,90
99 END

RUN


THE DISTANCE BETWEEN ( 0 , 0 , 0 ) AND ( 3 , 4 , 5 )
IS 7.071068

THE DISTANCE BETWEEN ( 3.5 ,-4.7 , 6.2 ) AND (-.9 , 3 , 4.4 )
I S 9.049309

THE DISTANCE BETWEEN ( 67 , 36 , 82 ) AND ( 54 , 25 , 90 )
I S 18.81489


READY
```

AREA: Mathematics
SOURCE: NREL/SDC

NUMBER:

NAME: EXPON
LANGUAGE: BASIC

DESCRIPTION: Program EXPON solves for x in any exponential equation of the form:

$$A^{mx+n} = B$$

given the values of A, B, m, and n.

The program solves the following problems:

1. $5^x = 50$
2. $5^{3x+1} = 7.6$
3. $17^{x-3} = 8.12$
4. $11^{1-2x} = 247$

APPROACH: If you were to solve an exponential equation by hand, you would probably go through the following steps:

$$5^x = 40$$

$$\log 5^x = \log 40$$

$$x \log 5 = \log 40$$

$$x = \frac{\log 40}{\log 5}$$

$$x = \frac{1.6021}{.6990} = 2.292$$

However, in the generalized form, the solution for x is:

$$x = \frac{\frac{\log B}{\log A}}{M-(N/M)}$$

A DATA statement was used to contain the data to solve problems 1-4 above. Modify the program to accept data using an INPUT statement to solve any exponential equation.

```
10 READ A,B,M,N
20 LET X=(LOG(B)/LOG(A))/M-(N/M)
30 PRINT X
40 GOTO 10
50 DATA 5,40,1,0,5,7.6,3,1,17,8.12,1,-3,11,247,-2,1
99 END

RUN

 2.29203
 .0867198
 3.739207
-.6487967

OUT OF DATA IN LINE 10


READY
```

2 6 10

AREA: Mathematics NUMBER: NAME: GOLDBACH
SOURCE: CAMP First Course, Scott, Foresman and Co. LANGUAGE: BASIC

DESCRIPTION: This is the description of the program exercise as it appears in the CAMP text (page 200).

"Goldbach's Conjecture is one of the famous unproved theories in mathematics. Many people have searched for a counter-example to prove that the following claim is false: Every even number E greater than four is the sum of two odd prime numbers. Study the program "Goldbach" which will print out each even number E, where $E<6<50$, and two odd prime numbers whose sum is E. Examine the output from the computer. Does this program "prove" the conjecture.

The teacher's guide is quick to point out that it proves the conjecture for $E \leq 50$, but that's all.

USAGE: Load Goldbach and type RUN. No input is required. This program has nested loops which take time. Running time is in minutes.

EDUCATIONAL BENEFITS: The student has whole new ways to approach theorem proving when the computer is available to try lots of cases.

```
LIST


  5 PRINT "GOLDBACH"
 10 FOR E=6 TO 50 STEP 2
 15 FOR P=3 TO E-3
 20 FOR F=2 TO P-1
 25 IF P/F=INT(P/F) THEN 65
 30 NEXT F
 35 FOR N=3 TO E-3
 40 FOR D=2 TO N-1
 45 IF N/D=INT(N/D) THEN 60
 50 NEXT D
 55 IF P+N=E THEN 80
 60 NEXT N
 65 NEXT P
 70 PRINT "CONJECTURE FALSE FOR"E
 75 GO TO 99
 80 PRINT E"="P"+"N
 85 NEXT E
 99 END

READY

RUN

GOLDBACH
 6 = 3 + 3
 8 = 3 + 5
 10 = 3 + 7
 12 = 5 + 7
 14 = 3 + 11
 16 = 3 + 13
 18 = 5 + 13
 20 = 3 + 17
 22 = 3 + 19
 24 = 5 + 19
 26 = 3 + 23
 28 = 5 + 23
 30 = 7 + 23
 32 = 3 + 29
 34 = 3 + 31
 36 = 5 + 31
 38 = 7 + 31
 40 = 3 + 37
 42 = 5 + 37
 44 = 3 + 41
 46 = 3 + 43
 48 = 5 + 43
 50 = 3 + 47


READY
```

AREA: Mathematics NUMBER: 8-6 NAME: GROUP
SOURCE: Digital Equipment Corp. LANGUAGE: BASIC
DESCRIPTION: This program illustrates a method of solving a mathematical word problem by trial and error using the computer. The problem is:

When 15 girls leave a group of boys and girls, there are 2 boys for each girl. After that, 45 boys leave. Then there are 5 girls for each boy. How many girls were in the group before anyone left?

USAGE: One must recognize that this problem requires the solution of two simultaneous equations. Letting G = the original number of girls and B = the original number of boys, the equations are:

$$(G - 15) \times 2 = B$$

$$(B - 45) \times 5 = (G - 15)$$

It is, of course, possible to substitute the value of B from Equation 1 into Equation 2 and solve for G. However, the computer permits us to get the solution by trial and error, obviously not a very sensible way to do the problem by hand.

The program below has been written to try all possible values of B and G between 1 and 100 until a solution is found or until the program runs out of combinations.

```
READY

 5 PRINT "PROGRAM GROUP"
 6 PRINT
10 FOR G=1 TO 100
20 FOR B=1 TO 100
25 LET I=I+1
30 IF 2*(G-15)<>B THEN 50
40 IF 5*(B-45)<>(G-15) THEN 50
45 PRINT G;"GIRLS",B;"BOYS"
48 GO TO 90
50 NEXT B
60 NEXT G
70 PRINT "NO SOLUTION"
90 PRINT I;"COMBINATIONS TRIED"
99 END

RUN

PROGRAM GROUP

 40 GIRLS       50 BOYS
 3950 COMBINATIONS TRIED


READY
```

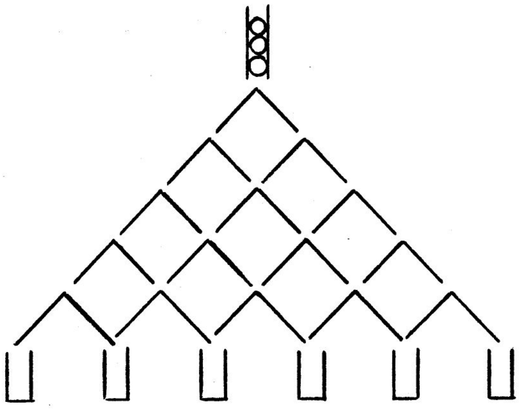
EDUCATIONAL BENEFITS: The student can see that the computer can be employed to find a solution to a problem by trial and error, but that it must try 3950 possible solutions before the correct one is reached. Hence, if a problem can be easily solved by hand, the computer may not always be a significant advantage.

```
RUN

PROGRAM PASCAL

HOW MANY BALLS? 1000
HOW MANY LEVELS? 1

 1               506
 2               494

HOW MANY BALLS? 1000
HOW MANY LEVELS? 2

 1               252
 2               501
 3               247

HOW MANY BALLS? 1000
HOW MANY LEVELS? 3

 1               117
 2               393
 3               376
 4               114

HOW MANY BALLS? 1000
HOW MANY LEVELS? 4

 1               56
 2               250
 3               366
 4               254
 5               74

HOW MANY BALLS? 1000
HOW MANY LEVELS? 5

 1               30
 2               135
 3               321
 4               317
 5               160
 6               37

HOW MANY BALLS? 1000
HOW MANY LEVELS? 6

 1               16
 2               102
 3               225
 4               323
 5               226
 6               93
 7               15

HOW MANY BALLS?
↑C

READY
```

AREA: Mathematics **NUMBER:** **NAME:** PASCAL
SOURCE: Digital Equipment Corp. **LANGUAGE:** BASIC

DESCRIPTION: This program simulates the dropping of N balls through the following array of K levels. It is assumed that each ball is equally likely to fall to the left or right at each point in the array. After each group of balls has been dropped, the number of balls in each basket (from left to right) is typed out.

The number of balls landing in the various "baskets" at each level, when reduced to the lowest common denominator, should approximate the numbers in Pascal's Triangle. Do they? Write a program to determine how close you come. You should be able to observe many interesting things about Pascal's Triangle. What are the sums of the numbers in each row? What is the progression of numbers in each diagonal?



```
  5 PRINT "PROGRAM PASCAL"
  6 PRINT
 10 DIM B(10)
 15 PRINT "HOW MANY BALLS";
 16 INPUT M
 17 PRINT "HOW MANY LEVELS";
 18 INPUT K
 20 PRINT
 30 FOR N=1 TO M
 35 LET T=0
 40 FOR L=1 TO K
 50 IF RND(1)>.5 THEN 100
 90 LET T=T+1
100 NEXT L
110 LET B(T+1)=B(T+1)+1
120 NEXT N
130 FOR L=1 TO (K+1)
140 PRINT L,B(L)
145 LET B(L)=0
150 NEXT L
160 GOTO 6
999 END

READY
```

1
1 1
1 2 1
1 3 3 1
1 4 6 4 1
1 5 10 10 5 1

Pascal's Triangle

AREA: Mathematics **NUMBER:** 8-8 **NAME:** PROGRS
SOURCE: Digital Equipment Corp. **LANGUAGE:** BASIC

DESCRIPTION: Sometimes the computer is used to do a problem in an entirely different way than we humans might approach the same problem. For example, given the following tables of values:

X	1	2	3	4	etc.
Y	10	17	26	37	

What is the value of X when Y is 2602?

APPROACH: We noticed that the difference between successive values of Y increases by 2 each step; i.e., 7, 9, 11, etc. Therefore, if we stepped from Y = 10 to 2602 in steps of Z, the step itself would have to be incremented by 2 for each new step. If we write a program to do this as well as count the number of steps, X, we should be able to solve the problem.

```
  5 PRINT "PROGRAM PROGRS"
  6 PRINT
 10 LET X=1
 20 LET Z=7
 25 LET Y=10
 30 LET Y=Y+Z
 40 LET Z=Z+2
 50 LET X=X+1
 60 IF Y<2602 THEN 30
 80 PRINT "X =";X,"Y =";Y
 99 END

READY

RUN

PROGRAM PROGRS

X = 49          Y = 2602


READY
```

EDUCATIONAL BENEFIT: It's often possible to solve a problem using the computer in a manner quite differently than one would use by hand. How would you have solved this problem not using the computer?

AREA: Mathematics NUMBER: NAME: QUADRT
SOURCE: Digital Equipment Corporation LANGUAGE: BASIC
DESCRIPTION: For any input values a, b, and c of a first degree quadratic equation ($ax^2 + bx + c = 0$), this program computes the roots of the equation.

APPROACH: Based on the quadratic theorem, given $ax^2 + bx + c = 0$, then

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Assuming a, b, and c are real numbers, the following principles are applied:

1. If $b^2 - 4ac$ is positive, then the roots are real and unequal.
2. If $b^2 - 4ac$ equals 0, then the roots are real and equal.
3. If $b^2 - 4ac$ is negative, then the roots are imaginary and unequal.

The program and several sample runs are on the reverse.

```
RUN

THIS PROGRAM SOLVES FOR THE ROOTS OF A
QUADRATIC EQUATION.  PLEASE INPUT THE FOLLOWING:
VALUE OF A? 1
VALUE OF B? 2
VALUE OF C? 1

THE ROOTS ARE
-1


THIS PROGRAM SOLVES FOR THE ROOTS OF A
QUADRATIC EQUATION.  PLEASE INPUT THE FOLLOWING:
VALUE OF A? 0
VALUE OF B? 2
VALUE OF C? 4

THIS IS A FIRST DEGREE EQUATION.
```

```
READY

10 PRINT "THIS PROGRAM SOLVES FOR THE ROOTS OF A "
20 PRINT "QUADRATIC EQUATION.  PLEASE INPUT THE FOLLOWING:"
22 PRINT "VALUE OF A";
24 INPUT A
26 PRINT "VALUE OF B";
28 INPUT B
30 PRINT "VALUE OF C";
32 INPUT C
34 PRINT
35 LET R=B↑2-4*A*C
40 IF A<>0 THEN 50
45 PRINT "THIS IS A FIRST DEGREE EQUATION."
47 GOTO 90
50 PRINT "THE ROOTS ARE ";
55 IF R<0 THEN 80
56 PRINT
58 IF R=0 THEN 70
60 PRINT (-B+SQR(R))/2*A
62 PRINT (-B-SQR(R))/2*A
65 GOTO 90
70 PRINT -B/2*A
75 GOTO 90
80 PRINT "IMAGINARY"
82 PRINT (-B/2*A);" + ";SQR(-R)/2*A;" *I"
84 PRINT (-B/2*A);" - ";SQR(-R)/2*A;" *I"
90 END

RUN

THIS PROGRAM SOLVES FOR THE ROOTS OF A
QUADRATIC EQUATION.  PLEASE INPUT THE FOLLOWING:
VALUE OF A? 2
VALUE OF B? 5
VALUE OF C? 2

THE ROOTS ARE
-2
-8


READY

RUN

THIS PROGRAM SOLVES FOR THE ROOTS OF A
QUADRATIC EQUATION.  PLEASE INPUT THE FOLLOWING:
VALUE OF A? 4
VALUE OF B? 2
VALUE OF C? 4

THE ROOTS ARE IMAGINARY
-4   +   15.49193   *I
-4   -   15.49193   *I


READY
```

AREA: Mathematics NUMBER: NAME: TUTOR-1
SOURCE: Walter Koetke, Lexington High School LANGUAGE: BASIC

DESCRIPTION: An effective technique for stimulating interest as well as for teaching methods of solving word problems is to have students write a program which will create and present a problem, ask the user to solve the problem, and then verify the user's response. For example, consider the problem:

A car traveling C (have computer generate an integer 40 through 65) miles per hour can make a certain trip in D (have computer generate an integer 5 through 20) hours less than a train traveling at T (have computer generate an integer 20 through 39) miles per hour. How long does the trip take by car?

The student's program should type out this problem with numbers generated by the random function appropriately substituted, then ask for the user's solution, the student's program must also correctly solve the problem. A program which does all of this is:

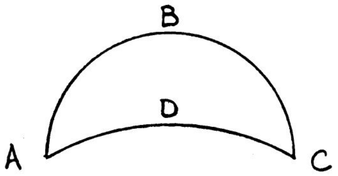
```
   5 RANDOMIZE
  10 LET C=INT(RND(0)*25)+40
  15 LET D=INT(RND(0)*15)+5
  20 LET T=INT(RND(0)*19)+20
  25 PRINT "A CAR TRAVELING"C"MPH CAN MAKE A CERTAIN TRIP IN"
   30 PRINT D"HOURS LESS THAN A TRAIN TRAVELING AT"T"MPH."
   35 PRINT "HOW LONG DOES THE TRIP TAKE BY CAR";
  40 INPUT A
  45 LET V=D*T/(C-T)
  50 LET E=INT(ABS((V-A)*100/A)+.5)
  55 IF E>5 THEN 70
  60 PRINT "GOOD!  ANSWER WITHIN"E"PERCENT."
  65 GO TO 80
  70 PRINT "SORRY.  YOU WERE OFF BY"E"PERCENT."
  80 PRINT "CORRECT ANSWER IS"V"HOURS."
  99 END

READY
```

```
RUN

A CAR TRAVELING 64 MPH CAN MAKE A CERTAIN TRIP IN
 12 HOURS LESS THAN A TRAIN TRAVELING AT 21 MPH.
HOW LONG DOES THE TRIP TAKE BY CAR? 6
GOOD!  ANSWER WITHIN 2 PERCENT.
CORRECT ANSWER IS 5.860465 HOURS.


READY

RUN

A CAR TRAVELING 53 MPH CAN MAKE A CERTAIN TRIP IN
 7 HOURS LESS THAN A TRAIN TRAVELING AT 23 MPH.
HOW LONG DOES THE TRIP TAKE BY CAR? 5
SORRY.  YOU WERE OFF BY 7 PERCENT.
CORRECT ANSWER IS 5.366667 HOURS.


READY

RUN

A CAR TRAVELING 43 MPH CAN MAKE A CERTAIN TRIP IN
 19 HOURS LESS THAN A TRAIN TRAVELING AT 27 MPH.
HOW LONG DOES THE TRIP TAKE BY CAR? 32
GOOD!  ANSWER WITHIN 0 PERCENT.
CORRECT ANSWER IS 32.0625 HOURS.


READY

RUN

A CAR TRAVELING 45 MPH CAN MAKE A CERTAIN TRIP IN
 7 HOURS LESS THAN A TRAIN TRAVELING AT 22 MPH.
HOW LONG DOES THE TRIP TAKE BY CAR? 7
GOOD!  ANSWER WITHIN 4 PERCENT.
CORRECT ANSWER IS 6.695652 HOURS.


READY
```

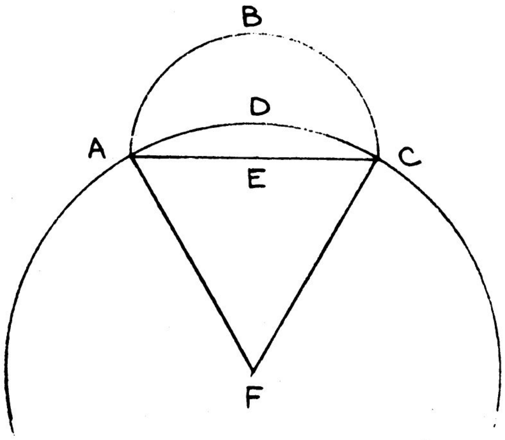
EDUCATIONAL BENEFIT: An effective use of this type of problem is to assign one problem from a list of several different problems to each student or to small groups of students. After the programs are written, students are directed to check programs written by others. In this way, each student not only fully understands the type of problem assigned to him, but he also gets practice in solving all of the other types as well. Note that the student must solve the problem in general in order to write his program. This should give him more valuable experience than solving two or three similar problems with specific numeric values.

AREA: Geometry NUMBER: 8-17 NAME: CRSCNT
SOURCE: Digital Equipment Corp. LANGUAGE: BASIC

DESCRIPTION: The computer is used to aid in the solution of the following problem. A crescent figure is bounded by a semicircle ABC whose radius is 5 inches and an arc ADC, the radius of whose circle is 10 inches. Find the area of the crescent.



APPROACH: In this problem, like any in which the computer is used, the student must recognize the fundamental formulae and algorithms to be used. If he cannot do that, he is stuck. To aid us in completing this problem, it will be helpful to complete the drawing to show more of both circles.



R1 = radius of small circle = 5
R2 = radius of big circle = 10

Some things should now be apparent. In particular, since ABC is a semicircle, distance AEC is equal to 2*R1 = 10. Hence, triangle ACF is equilateral. Therefore, the area of wedge ADCF equals 1/6 the area of the large circle. Hence, the area of the crescent is:

$$\begin{aligned}\text{Area}_{\text{crescent}} &= \text{Area ABCE} - \text{Area ADCE} \\ &= \frac{1}{2} * \text{Area}_{\text{small circle}} - \left[\text{Area}_{\text{wedge}} - \text{Area}_{\text{triangle}}\right] \\ &= \frac{1}{2} * \pi * R1^2 - \left[\frac{1}{6} * \pi * R2^2 - \frac{1}{2} * R2 * \sqrt{R2^2 - \left(\frac{R2}{2}\right)^2}\,\right]\end{aligned}$$

We can now substitute 5 and 10 for R1 and R2, reduce the equations and solve. The typical math text would ask that the answer be left in radical form and not figured for π. After a good bit of manipulation, the student would finally get down to an answer of:

$$\text{Area}_{\text{crescent}} = 25 * \left(\sqrt{3} - \frac{\pi}{6}\right)$$

However, using the computer, we can get a final solution without a lot of hand reduction.

```
  10 LET P1=3.14159
  20 PRINT "AREA OF CRESCENT IN SQUARE INCHES IS";
  30 PRINT 1/2*P1*5↑2-1/6*P1*10↑2+1/2*10*SQR(10↑2-5↑2)
  99 END

READY

RUN

AREA OF CRESCENT IN SQUARE INCHES IS 30.21131


READY
```

EDUCATIONAL BENEFITS: The student can see that the computer won't help him much unless he knows the problem fundamentals and can "teach" the computer how to help him. He also learns that the computer is happy to grind through calculations that aren't very pleasant to do by hand. Of course, if he wants to reduce the equation as far as possible and then use the computer, that approach works too.

```
  10 LET P1=3.14159
  20 PRINT "AREA OF CRESCENT IN SQUARE INCHES IS";
  30 PRINT 25*(SQR(3)-P1/6)
  99 END

READY

RUN

AREA OF CRESCENT IN SQUARE INCHES IS 30.21131


READY
```

AREA: Statistics **NUMBER:** 8-19 **NAME:** FLIP-1
SOURCE: Basic BASIC, Hayden Publishing Co. **LANGUAGE:** BASIC

DESCRIPTION: This program makes use of the random number generator in BASIC to flip an imaginary coin and do a simple tabulation of the number of heads which come up. Ten sequences of 50 flips are tabulated.

APPROACH: Since the random number generator, RND, produces numbers between 0 and 1, we must have a way of splitting the numbers in half. One way, of course, is to ask whether the random number generated is greater or less than .5. Another way, which illustrates the use of the integer function, is as follows. Multiply the random number generated by 2 and then take the largest integer value contained in the result. If 0, let it be a tail; 1, a head. The statement to set the value of the flip is:

```
LET F = INT (2 * RND (1) )
```

Now, let's see what the whole program looks like.

```
  1 PRINT "PROGRAM FLIP-1"
  4 FOR Y=1  TO 10
  5 LET C=0
 10 FOR X=1  TO 50
 20 LET F=INT(2*RND(1))
 30 IF F=1  THEN 60
 40 PRINT "T";
 50 GO TO 100
 58 REM  C COUNTS THE NUMBER OF HEADS
 60 LET C=C+1
 70 PRINT "H";
100 NEXT X
110 PRINT
120 PRINT "HEADS";C;"OUT OF 50 FLIPS"
122 PRINT
125 NEXT Y
999 END
```

```
READY

RUN

PROGRAM FLIP-1
TTHTTTTTHTTTTHTHTTHHHTTTTHHHTTHHHHHTHHHHHHTTHHTTHT
HEADS 24 OUT OF 50 FLIPS

THTTHHHTHHTHHHHTTTHTHTHHTTHHHHHHTTTHHTHTTHTTTTTHTT
HEADS 25 OUT OF 50 FLIPS

THTTHTHHTTTHHHHHTHTHTTHHHTTHTHHTTHHTHHTTHTTHTHTHTT
HEADS 25 OUT OF 50 FLIPS

HTHTTTHTTTTHHHHHHTHHTTHTTTTHHHHTHTTTTHTTHTHHTTTHT
HEADS 23 OUT OF 50 FLIPS

HHTHTHTTTHHTHTTTHTTTHTHTTTHHTTTTTTHTHTTHHHHTHTHHTT
HEADS 21 OUT OF 50 FLIPS

THHHTHHTTTHHTHTHTHHHTHTHTTTTTTTTHHTHHHHHTTHHTTTHTH
HEADS 25 OUT OF 50 FLIPS

THHTHTHHTHHTHHTHTHHHHHHTTHTTHHHHTHHTTTHTHHHHHTTHHHT
HEADS 31 OUT OF 50 FLIPS

TTTHTTTTHTHHTTHTHTHTHTTHHTTHTTTHTHHHTHHHHTHHHHHHHH
HEADS 27 OUT OF 50 FLIPS

HHHHTHHHHHTHHHTHTHHTTHHHHTTHHTTHTHTHHTTTTTHTTTTHHH
HEADS 29 OUT OF 50 FLIPS

TTTHTHTTTTTTHTHTHTTTHTTHHTHTHHHTTHHHTHHHTHTHHHTHTT
HEADS 23 OUT OF 50 FLIPS
```

A simple addition lets us compute the percentage of all 500 flips which were heads.

```
2 LET C1=0
65 LET C1=C1+1
130 LET A=C1*100/500
133 PRINT
135 PRINT A;"% OF 500 FLIPS WERE HEADS"

RUN

PROGRAM FLIP-1
TTHTTTTTHTTTTHTHTTHHHTTTTHHHTTHHHHHTHHHHHHTT
HEADS 24 OUT OF 50 FLIPS
                                                  ...THHHHHHHH

THTTHHHTHHTHHHHTTTHTH
HEADS 25 OUT
                         ...HTTHHHHTTHHTTHTHTHHTTTTTHTTTTHHH
           OUT OF 50 FLIPS

TTTHTHTTTTTTHTHTHTTTHTTHHTHTHHHTTHHHTHHHTHTHHHTHTT
HEADS 23 OUT OF 50 FLIPS


 50.6 % OF 500 FLIPS WERE HEADS


READY
```

AREA: Plotting NUMBER: NAME: SINEX
SOURCE: Digital Equipment Corp. LANGUAGE: BASIC

DESCRIPTION: The computer can be used to plot virtually any function. This particular method takes advantage of the TAB command, although it need not. For example, a program to plot a sine wave without using TAB, would be as follows:

```
1 FOR X=0 TO 19 STEP .25
2 LET Q=30+30*SIN(X)
3 FOR B=1 TO Q
4 PRINT " ";
5 NEXT B
6 PRINT "X"
7 NEXT X
9 END
```

In the next program, we have filled in the area between the y axis and the curve and we have used the TAB command to replace steps 3 to 5 above.

```
31 FOR X=0 TO 19 STEP .25
32 LET Q=30*SIN(X)*EXP(-.1*X)
33 IF Q>=0 THEN 35
34 GO TO 42
35 PRINT TAB(30);
36 FOR Y=0 TO Q
37 PRINT "X";
38 NEXT Y
40 PRINT
41 GO TO 50
42 PRINT TAB(30+Q);
43 FOR Y=0 TO Q STEP -1
44 PRINT "X";
45 NEXT Y
46 PRINT
50 NEXT X
99 END
```

```
RUN
                              X
                              XXXXXXXX
                              XXXXXXXXXXXXXX
                              XXXXXXXXXXXXXXXXXXX
                              XXXXXXXXXXXXXXXXXXXXXXX
                              XXXXXXXXXXXXXXXXXXXXXXXXXX
                              XXXXXXXXXXXXXXXXXXXXXXXXXX
                              XXXXXXXXXXXXXXXXXXXXXXXXX
                              XXXXXXXXXXXXXXXXXXXXXXX
                              XXXXXXXXXXXXXXXXXXX
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                              XXXXXXXX
                              XXXXXXXX
                              XXXXXXX
                              XXXXXX
                              XXXXX
                              XXX
                              XX
```

AREA: Plotting NUMBER: NAME: 3DPLOT
SOURCE: Digital Equipment Corp. LANGUAGE: BASIC

DESCRIPTION: 3DPLOT will plot a three dimensional, perspective graph of a function of three variables. It plots Z (the vertical axis) as a function of X and Y, where X and Y are inside a circle of radius 30.

USAGE: Enter the function to be plotted as a DEF FNA(Z) statement in line 5. Then type RUN. The resulting plot will go sideways on the page.

```
  5 DEF FNA(Z)=SQR(900.01-Z*Z)*.9-2
 40 PRINT
 45 LET I1=1
 50 FOR X=-30 TO 30 STEP 1.5
 60 LET L1=-1
 70 LET Y1=5*INT(SQR(900.01-X*X)/5)
 80 FOR Y=Y1 TO -Y1 STEP -5
 90 LET Z=INT(25+FNA(SQR(X*X+Y*Y))-.7*Y)
100 IF L1=-1 THEN 140
110 IF Z>L1 THEN 180
120 IF Z<L2 THEN 150
130 GO TO 200
140 LET L1=Z
150 LET L2=Z
160 IF Z=I1-1 THEN 166
161 FOR I=I1 TO Z
162 PRINT " ";
164 NEXT I
166 PRINT "*";
167 LET I1=Z+2
170 GO TO 200
180 LET L1=Z
190 GO TO 160
200 NEXT Y
210 PRINT
215 LET I1=1
220 NEXT X
230 PRINT
240 END

READY
```

Like all plotting programs, some functions come out "prettier" than others. Two that are known to work are:

```
5 DEF FNA(Z) = 30*EXP(-Z*Z/100)

5 DEF FNA(Z) = SQR (900.01-Z*Z)*.9 -2
```

```
5 DEF FNA(Z)=30*EXP(-Z*Z/100)

RUN


                         *
                     *   *  *
                  *  *   *  *   *
              *   *  *   *  *   *  *
              *   *  *   *  *   *  *
              *   *  *   *  *   *  *
           *  *   *  *   *  *   *  *   *
           *  *   *   *  *   *  *  *   *
           *  *   *   *   *  *  *  *   *
       *   *  *   *    *  *   * *  *   *  *
       *   *  *    *   *    * *  * *   *  *
       *   *   *   *     *   *  **  *  *  *
       *   *   *    *      *    * * *  *  *
       *   *   *     *       *    * *  *  *
       *   *   *      *        *      **  *
       *   *    *       *         *       *
       *   *    *        *           *       *
       *   *     *         *            *        *
       *   *     *          *             *         *
       *   *     *          *               *         *
    *  *   *     *           *              *          *
       *   *     *          *               *         *
       *   *     *          *             *         *
       *   *     *         *            *        *
       *   *    *        *           *       *
       *   *    *       *         *       *
       *   *   *      *        *      **  *
       *   *   *     *       *    * *  *  *
       *   *   *    *      *    * * *  *  *
       *   *   *   *     *   *  **  *  *  *
       *   *  *    *   *    * *  * *   *  *
       *   *  *   *    *  *   * *  *   *  *
           *  *   *   *   *  *  *  *   *
           *  *   *   *  *   *  *  *   *
           *  *   *  *   *  *   *  *   *
              *   *  *   *  *   *  *
              *   *  *   *  *   *  *
              *   *  *   *  *   *  *
                  *  *   *  *   *
                     *   *  *
                         *


READY
```

EDUCATIONAL BENEFITS: Using the computer to plot is an excellent way to teach coordinate geometry. It really shows the interrelation of geometry and algebra as described by Descartes.

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